DOCUMENT RESUME

ED 417 981 SE 061 316

AUTHOR	Boyle, Robert A.; Skopp, Lori
TITLE	Teachers as Inquirers: Constructing a Model of Best Practice.
SPONS AGENCY	National Science Foundation, Arlington, VA.
PUB DATE	1998-04-22
NOTE	22p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (71st, San Diego, CA, April 19-22, 1998).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Action Research; Constructivism (Learning); Educational Change; *Hands on Science; *Inquiry; Inservice Teacher Education; Intermediate Grades; Junior High Schools; Knowledge Base for Teaching; Middle Schools; *Professional Development; *Science Instruction; *Science Teachers
IDENTIFIERS	National Science Foundation

ABSTRACT

This paper reports on a study of inquiry and teacher development in a middle school science reform project. A model was developed that examined the dialectical interaction between teachers' concerns about their classroom practice and the culture of their professional setting, the school. This model sees the interaction of these two concerns as a zone of proximinal development for teachers. An examination of the literature shows support for how this model can explain both the successes and the breakdowns that occur in this zone. The project, Scientific Process, Practice, and Presentation: Applying Resources and Knowledge (SPARK), is the source of the data for this study. The goal of SPARK is to promote and support systemic change within middle schools in terms of teacher practice, student activity, and school culture. Contains 18 references. (DDR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 417 981

Teachers as Inquirers:
Constructing a Model of Best Practice

Robert A. Boyle
Lori Skopp
New York Academy of Sciences

PERMISSION TO REPRODUCE AND
DISSEMINATE THIS MATERIAL HAS
BEEN GRANTED BY

R. Boyle

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)

1

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Paper presented at the Annual Meeting of the
National Association for Research in Science Teaching
April 22, 1998 – San Diego, CA

2 East 63rd Street
New York, NY 10021
T: 212.838.0230
F: 212.838.5810
E: nyas@nyas.org
http://www.nyas.org

Serving Science,
Technology, and
Society Worldwide
Since 1817

BEST COPY AVAILABLE

SE 061 314

Engaging in inquiry means keeping an open yet skeptical mind. This is as true of learning science in classrooms as it is of studying how such science is taught. Studying the teachers participating in SP^{3}ARK, an NSF-funded middle school science reform project, has led us to revise our conceptions of the path their development would take. In the course of investigating the path our teachers described, we developed a model of examining the dialectical interaction between teacher's concerns about their classroom practice and the culture of their professional setting, the school. This model sees the interaction of these two concerns as a zone of proximal development for teachers. An examination of the literature shows support for how this model can explain both the successes and the breakdowns that occur in this zone.

This project was supported, in part,
by the
National Science Foundation
Opinions expressed are those of the authors
and not necessarily those of the Foundation

Teachers as Inquirers:
Constructing a Model of Best Practice[1]

One of the wonders of teaching children science through inquiry is that they ask the questions, devise the solutions, and provide the explanations that would never occur to us as their mentors. Why should we expect anything less from teachers engaged in teacher enhancement and reform projects based on a model of inquiry?

Abell and Flick's (1997) editorial *Who Do We Think We Are Anyway?* is a thoughtful, timely cautionary tale for researchers of science teaching and learning. As we come from outside the classroom with our theories of what "should" be taking place inside, it is essential that we inquire into what actually takes place rather than critique such practice as seen through our frameworks. We need to ask teachers about their own practice and, through listening, try to *develop* our understanding of inquiry-based science. This perspective on conducting research is consistent with the ethic of grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1990), of listening to members of the field of study and constructing a theory of their practices based in their everyday actions. Such an approach complements our more theoretical knowledge base as well. Bringing field and disciplinary knowledge together helps us shape a language and framework for inquiry based both upon the "day-to-day activity of teaching" and our theoretical understanding of science teaching (Abell & Flick, 1997).

These concerns help to frame our work described here. When we began this study, we approached it with the following questions in mind: To what extent do the project's lead teachers incorporate a process of inquiry into their own practice? To what extent are the lead teachers able to develop a learning community within their science departments? How does this community function as a means of changing the practice of the department as a whole? These questions reflect our project's core goals. What we discovered in listening to our project's teachers is that the story is more involved and less linear than we had imagined; our analyses answer questions different from those we had originally asked. Still, our focus remains the same—on how teachers involved with changing their practice towards inquiry-based instruction approach this task and how they reconstruct themselves in the process.

SP^{3}ARK: The Context of our Study

This work was conducted in the process of studying teachers participating in Scientific Process, Practice and Presentation: Applying Resources and Knowledge (SP^{3}ARK), a middle school science reform initiative of the New York Academy of Sciences funded by the National Science Foundation. Robert Boyle is the project director, and Lori Skopp is the principal investigator. A description of this project will aid in understanding both the broad context for this work and the forestructure (Addison, 1989) we have brought to this study.

SP^{3}ARK's goal is to prompt and support systemic change within middle schools in terms of teacher practice, student activity, and school culture (Figure 1). The centerpiece of this project is the development of a student science exhibition that moves away from the show-and-tell model of traditional science fairs towards an opportunity for students to share the results of inquiries and investigations they have devised and conducted throughout the school year (similar to, for instance, the annual meeting of a science research association). Our primary means of working towards this goal is through teacher enhancement activities augmented by support for departmental and school level reforms that assist the implementation of an inquiry based science program.

The approach to inquiry science instruction emphasized in our workshops does not favor any one particular curriculum series or model, but helps teachers develop skills necessary for mentoring inquiry-based learning. Depending on an individual teacher's expertise, some apply these skills in straight-forward implementations of kits, others adapt these kits and other commercial materials for their own units and curricular needs, still others devise inquiry lessons from common materials easily obtained from supermarkets, homes, or other sources available. By focusing on the pedagogy of inquiry learning rather than the mechanics of a particular curricular program, our teachers learn how they can best act as science mentors for their students, moving from a traditional, didactic model to an apprenticeship model of instruction.

Our project started with the intense training of two to three lead teachers from each of four participating New York City middle schools, consisting of a two-week summer institute on inquiry science and an additional three days on leadership skills and prompting organizational change. One of our lead teachers, at the time, described this approach as a "viral model," infecting a few teachers in each school and creating conditions for the model to spread first to other teachers and then eventually to entire science departments and administrations. Indeed, this level of commitment and willingness to change at the departmental and administrative level was a prerequisite for school participation in the project. This approach is also illustrated in our three original questions, looking for change first in lead teachers, next in individual colleagues, and finally in a department and school's unified, systemic commitment to an inquiry-based science program for all grades.

The linearity of our model with its assumed steady progress throughout the science faculties of our partner schools was quickly called into question by the demands and needs the lead teachers related to us at the end of the summer institute. Already they were informing us of the amount of time they would need to implement this approach well enough to act as mentors for their colleagues. Competing with this concern, beginning in September, was the desire and eagerness of the other teachers to learn from their colleagues and benefit from the training the lead teachers had received. Actual implementation by the lead teachers began to clarify these concerns—addressing and answering some, exacerbating others, and raising new concerns none of us perceived during the prior summer.

Our original plan for this research called for case studies but in the face of these concerns and how they interacted with our project teachers' practice, an examination of the breadth of these issues was more important than the depth of focus that case studies would provide. In this study, we investigate how teachers construct the problem of becoming an inquiry teacher, the dimensions of this problem and their character as seen through the field experience of our colleagues. Part 1 of our analysis below describes two dimensions useful in understanding this problem and how we arrived at them. Part 2 uses qualitative data from a variety of contexts to illustrate how these dimensions influence teacher practice and teacher change.

Part 1: Our Practice, Our Profession

Evaluations of an Inquiry Workshop

Last January, SP^{3}ARK held its first workshop[2] involving school personnel other than the original nine lead teachers. Among the twenty-one participants were nineteen classroom teachers and two administrators. The workshop itself was a full-day introduction to inquiry-based science; to be followed later in the year by a series of other workshops on more advanced topics. During the workshop, the participants worked in small groups investigating the nature of static electricity with a variety of commonly available materials (e.g., balloons, combs, fabrics, puffed rice). After a period of exploration, groups were prompted to develop investigable questions and asked to pursue these questions through an experiment of their own design. The afternoon was spent in

group presentations and a summary discussion examining the scientific validity of each group's work and looking for general principles that could be drawn from the evidence generated by these studies. The workshop ended with an open discussion of the pedagogical aspects of inquiry science and how participating teachers could begin implementing what they learned.

Participants were asked to fill out an evaluation of the workshop at the end of the day. This open-ended questionnaire asked participants to identify up to three strengths and weaknesses of the workshop, rate each issue as to its importance, and provide comments on the nature of each issue (see Appendix for a description of this instrument). While this questionnaire was ostensibly an evaluation of the workshop, its open-ended nature was also a reflection of the concerns the participants found most important with respect to inquiry instruction and changing their classroom practice.

Tables 1 and 2 list some basic descriptive statistics about the data gathered through this evaluation. Table 1 lists the number of issues identified by each participant. For the positive comments, 20 of the 21 participants gave three comments, the last giving two, for a total of 62 out of a possible 63 comment. There was much more variability between participants in how many negative comments were made, ranging from three to no comments made by individuals but totaling only 17 of 63 possible comments. Table 2 examines the ratings given to each comment on a four-point scale (1 indicating a minor strength/weakness, 4 indicating a major strength/weakness). Taken together, these data indicate that the workshop was quite influential (positive comments per person M=2.95, SD=0.22; ratings M=3.36, SD=0.74) while still eliciting areas of concern for the participants (negative comments per person M=1.10, SD=1.04; ratings M=2.24, SD=0.67). We chose not to conduct further statistical analyses of these data due to issues with missing data; specifically, the problems that arise in interpreting the lack of response with the negative comments. Readers are referred to the full report on this evaluation (New York Academy of Sciences, 1998)[3] for an in-depth discussion of this issue.

Although these figures give some overall sense of the participants' response to the workshop, our primary concern here is not how the numbers illustrate the participants' opinions on the effectiveness of the workshop. Instead, the nature of these statements and the issues they identify are our focus. All four project schools were equally represented, and the number of participants comprised approximately one-third of their combined science faculties. Thus, the participants represent a fair cross-section of the teachers involved with SP^{3}ARK. This base gives us our best data to measure the concerns that our project teachers face in attempting to change their practice towards an inquiry approach to science.

Identifying Teacher Concerns

Beyond the numbers generated by our evaluation instrument are the issues that teachers identified. We examined these data by means of a constant comparative analysis (Glaser & Strauss, 1967) of these issues. Positive issues (N=62, cf. Table 1) and negative issues (N=17) were kept separate in the initial stages of our analysis. Our method at the first level of analysis consisted of creating "cards" for each issue, maintaining the original wording of each issue. Starting with one card placed on a tabletop, additional cards were juxtaposed with the first to examine the conceptual similarity between them. A card that was similar to the referent was placed next to it, forming a conceptual group. Cards that were seen as conceptually different from the referent card were placed a distance from the referent indicative of the degree of distinction. By making such comparisons as cards are added, a conceptual map emerges from the data. Placement decisions were revisited frequently, to check against the need to subdivide a group or to merge groups that develop a common bond. In several cases it became apparent to us that one particular issue statement could belong to two different groups; these were cross-coded as belonging to both.

BEST COPY AVAILABLE

Once groups were formed and checked with all the cards for each of the positive and negative issues, we assigned category names to each group. Wherever possible, category names utilized the wording of the participants in order to represent faithfully the participants' meanings. We then conducted a second level of comparative analysis on the categories themselves, to examine any higher-order relationships between these issues. The results of this analysis are shown in Tables 3a-b, expressed as themes and including each theme's mean ranking, mean rating, and the number of comments belonging to this grouping. The themes are listed in order of the lowest mean rankings (a ranking of 1 indicates an issue as identified first). By ranking, we refer to whether the comment was made first, second, or third on the appropriate page of the instrument. This ranking, parallel to the ratings given by participants, is suggestive of a separate measure of importance: what comes first to mind. In examining these tables, the reader should note that the total number of comments coded exceeds the figures listed in Table 1 due to the cross-coding of statements. For two of the positive themes we identified subthemes, thus providing even greater detail in describing the concerns raised in these areas. While one may argue that the subthemes deserve equal footing with the other major themes, their cohesion towards a higher-order concept and that superordinate concept's similarity to the structural level of the other themes lends support to our coding scheme as it is described in Tables 3a-b and below.

We identified six positive themes: social issues, methods, materials, curriculum, models, and miscellaneous. The social issues and the methods themes were further divided into three and five subthemes, respectively. Below are descriptions of each theme:

- *Social*—issues related to social interactions and working in groups of participants, these can be further divided by role, the instrumental nature of groupwork, and the opportunities for discussions between groups.
  - *Social: peer interaction*—these comments dealt specifically with the fact that workshop participants were colleagues. Comments focused on the chance to interact and collaborate with fellow teachers, seeing and sharing what they do in their own classrooms with one another or how they would adapt the new methods learned to such practice.
  - *Social: groupwork*—these comments centered on the value of working as a group of learners. While most simply mentioned the value of groupwork, other more specific comments pointed out the value of teams and the pooling of prior knowledge and different experiences of each group member.
  - *Social: discussion*—these comments centered on the exchange of ideas and discoveries, particularly those occurring during the whole-group discussion. Listening to others as well as having the opportunity to question their findings were both found of value.
- *Method*—this group of themes centers on concerns about the teaching methodology of science.
  - *Method: time*—participants commented on the large "chunk of time" allotted to exploring the materials and doing an investigation.
  - *Method: hands-on*—taking a hands-on, active learning approach was central to this group of comments.
  - *Method: freedom*—important for this theme was the open approach to inquiry modeled, allowing for freedom and variety, with an appropriate level of structure.
  - *Method: review*—for one lead teacher, reviewing the methods of inquiry was important.
  - *Method: inquiry*—this theme centered specifically on the nature of inquiry-based science instruction and how it differs from more traditional approaches to science.
- *Materials*—numerous comments were made about the "unlimited" materials available for exploring the topic, allowing for freedom and variety. The materials were also quite common, which was seen as still another strength.
- *Curriculum*—Two specific comments were made on curriculum issues. One mentioned the interdisciplinary approach that inquiry makes available; the other pointed out the discussion held on addressing state and national science standards.

- *Models*—Several comments brought to attention the job the workshop leaders did in modeling inquiry instruction, as well making general comments on the quality of the staff.
- *Miscellaneous*—One comment was made about the food provided, and how this was an important perk for getting teachers to attend and participate.

As Table 3a illustrates, all of these themes had mean ratings between 3 (This was very important) and 4 (This was essential). The *Social* and the *Method* themes ranked about evenly, and both contained the most highly rated concerns (of those with more than one statement coded to them). *Social: peer interaction* was both highly ranked and rated, indicating the centrality of this theme to those who mentioned it. Also of interest for this theme is the effect of one participant's atypically low rating of a relevant issue. If this outlier is removed, the mean for *Social: peer interaction* becomes 3.71 (SD=0.49; ranking M=1.43, SD=0.53). Three related themes—*Method: inquiry*, *Social: discussion*, and *Models*—all show the interesting pattern of having moderate to low rankings yet some of the highest ratings, placing them high in terms of both measures of importance.

Six negative themes were identified as well: time (too much), time (too little), structure, content, modeling, and miscellaneous. At first, it might seem that the two time themes should be related. In our analysis, they have been kept separate since, unlike the similarly related positive themes, these two are related in that they express opposing sentiments. Thus, keeping them separate helps highlight the distinction between them. Below are descriptions of each theme:

- *Time: too much*—the most common negative statement, participants focused here on too much time being spent experimenting, while some added that more structure was also needed.
- *Time: too little*—other participants chose to comment on time constraints in terms of a lack of time for discussion (which does not necessarily imply that too much time was spent experimenting) or a need for more than a one day workshop.
- *Structure*—a lack of structure or focus was also cited, and this was often connected to the amount of time spent experimenting.
- *Content*—one participant made three comments related to the content of the workshop, focusing on the need for more vocabulary, assessment, and relevance.
- *Modeling*—three respondents thought that more modeling and explanation of the science encountered was needed. This may also be an issue of time and/or structure.
- *Miscellaneous*—One lead teacher commented that the workshop was essentially a repetition of what the lead teachers had experienced in the previous summer's workshop.

Due to the much lower response rate for negative comments and thus a lack of variability in their rankings compared to the positive comments, interpreting the rankings becomes much more difficult. What is clear, though, is that the participants felt very strongly about the allocation of time during the workshop. Approximately half of the comments were made on these two themes, and every one was ranked first. It is worthwhile to note as well that 15 of the 21 respondents made no or only one negative comment; thus, many of the time-related negative comments were the only weakness identified by those respondents.

Overall, this level of analysis provides a powerful examination of how the workshop in which these educators participated addressed or ignored their needs (NYAS, 1998). It also allows us to identify the major patterns through which these needs were expressed. What it fails to do, however, is leave the context of the workshop and focus entirely on the nature of those needs. Thus, the separation of the positive and negative comments may meet the needs of the workshop leaders in improving the workshop, but it also creates an artificial divide in teacher concerns that may hide deeper relationships between the themes.

A Dialectic of Concerns

In examining other data sources from the SP³ARK project, we began to recognize that a deeper conceptual level might exist beyond the themes we identified in our original analyses of the workshop evaluation. To address this, we conducted a final level of comparative analysis at the thematic level, putting aside during this process the distinction between issues identified as strengths versus weaknesses of the workshop.

The nature of the data, drawn from a workshop on changing teaching methods, did create some limitations in this analysis. However, cross comparison with our other project data helped to elucidate the nature of these limitations, lending some clarity to the current process. Comparing themes led us to distinguish between two foci—those issues centered on interactions with students and those on interactions with colleagues. Another way of describing this distinction is whether the teacher's concern lay with her *practice* or her *profession*. Figure 2 depicts how the themes relate to these concerns (the +, –, and ± indicating whether the theme was a strength, weakness, or both). As this figure illustrates, the data from these evaluations load primarily as concerns about practice, a reasonable expectation given the focus of the workshop. As with the previous level of comparative analysis, where we devised our themes from the code categories, the themes (as illustrated by the statements of which they consist) also show some need for cross-coding. These themes are listed at the bottom of Figure 2.

We propose here the consideration of these two concerns as fundamental dimensions in the task that teachers face in changing how they teach. By *practice concerns*, we mean issues that are related specifically to a teacher's primary task of teaching science to students. The locus of this concern is the classroom, and it exists primarily between the teacher and his students. By *profession concerns*, we mean issues that are related to the teacher's membership in a professional community. The locus of this concern is the culture of the school and of teaching, and it exists primarily between the teacher and his colleagues, both teachers and administrators.

That these two concerns span the strengths and weaknesses of the workshop raises several interesting questions. The concerns raised certainly may underlie a broader range of events than teacher enhancement workshops, particularly this one event. Thus, data collected from other types of events (e.g., classroom activity, departmental program development) needs to be examined to map their range. The load bias of themes onto practice concerns also suggests that there may be deeper issues of profession concerns that these data do not illustrate. Events that center primarily upon professional collaboration and interaction are needed to examine a richer context for these concerns. The cross-coding of themes suggests a high level of interaction between these concerns. Considering this, it may be most useful to view these two concerns as creating a dialectic. Thus, the nature of their interaction—when are they antagonists? do they necessarily interact? can their constructive interaction create a synthesis greater than the simple sum of the two?—becomes an important and intriguing issue to investigate.

Pursuing these questions requires a richer base of data than provided by these workshop evaluations. In the second part of our study, we engage in an interpretive analysis of a variety of qualitative data based upon this dialectic. Through this analysis, we examine what support exists for these concerns and, given their presence, how they interact in a variety of contexts.

Part 2: Examining A Dialectic of Concerns

Our Research Approach

We chose to examine three sets of qualitative data gathered from SP³ARK for the second half of our study. In particular, these data are: (1) a set of letters lead teachers wrote to themselves at the end of the summer institute, to be delivered at the beginning of the school year and four months into the year, on what goals they hoped to achieve by these times with respect to

changing their practice and leading their colleagues in reforming their science programs; (2) a teacher's personal journal recording events in his classroom and his reflections during the first month of the school year, and (3) the transcript of an interview with two of the project's lead teachers reflecting back upon their challenges and accomplishments in implementing change up until that point in time. These data provide rich descriptions of teacher concerns generated through different means and in different contexts.

In examining these data for evidence of the practice and profession concerns, we have employed an interpretive coding scheme similar to that of Gilligan (1982). In her work on moral development, Gilligan identifies two ethics—the ethic of care and the ethic of justice—and uses these to interpret the extent to which subject responses in a variety of studies elucidate the nature of each ethic and how they relate to one another. We have used the practice and profession concerns in a similar manner, examining what evidence of them exists in our data and studying how they interact dialectically. The text of each data source was coded for the presence of both concerns. Once this was complete, we compiled supporting statements for each concern separately and constructed a narrative account for each, using the codes for detail and specific wording, in order to better understand the nature of each on its own. The themes of which teacher concerns were constructed (Fig. 2) were used as a guide for interpretation. We found that they also aided in identifying issues not present in the workshop evaluation that were still consistent with practice and profession concerns. Finally, we compared these accounts for each data source, returning to the data to examine instances where the codes coincide and considering broader issues of interaction made evident by the narratives. Finally, we summarize and integrate these findings in our general discussion to complete this part of our study.

Context One: Teacher Letters

We examined 6 letters—pairs of letters written by three teachers. As mentioned above, the teachers wrote these letters in July, to be delivered back to them in September and December with messages for themselves. Teachers were asked to describe in the first letter what issues they would need to address at first in terms of their teaching and of their work with their colleagues. The second letter asked teachers to focus on what they would hope to accomplish by the time the letter is returned to them. Given the nature of these tasks, the division between practice and profession was already established to a significant extent and, as a result, we did not expect many interactions to take place. We also expected this format to generate roughly similar amounts of statements on each of these concerns. In fact, profession codes outnumbered practice codes two-to-one, and thus provided valuable information on the profession concern absent from the workshop evaluations. These letters generated 46 coded statements (15 primarily practice-related, 31 primarily profession-related), and we used these to generate the descriptions of the concerns below.

- *Practice:* A critical feature of inquiry classroom practice is student empowerment. Students need to be capable of formulating questions they can answer through experiments they design. They should be able to illustrate scientific concepts through their experiments. They should be capable of sharing their data with their fellow students. This should lead to high levels of student excitement and success. Teachers need to support students in this effort. First of all, they need to let go of the reins and allow students to assume some control over their own learning. Teachers need to be science role models, but they also need to step in directly when students need firmer support. Teachers need to improve their ability to ask open-ended questions, reflecting on this skill to improve their own technique and modeling it for students to promote skeptical inquiry and discussion. Teachers also need to examine their own tools, particularly curriculum materials and assessment instruments, to make sure they are in line with inquiry science.

- *Profession:* Teachers need to talk to one another. They need to develop mechanisms, such as regular meetings, colleague observations, and shared planning time to promote this communication. This change process does not need to be faced alone, nor should it be. Teachers

can act as mentors and models for one another; they can also act as critical observers capable of providing meaningful suggestions to improve one another's practice. Teachers need to support each other in this process of change, and they need to be reflective about their own practice as well. Teachers facing a change towards inquiry need to see more than how to do it—they need to see how it can succeed and how it can help their students learn science and enjoy doing so. This communication needs to be planned, but it also needs to be invited. It needs to be approached through an atmosphere of open sharing. Teachers also need to pay attention to structural issues that will shore up this process of change. Administrators need to be kept informed of the progress of change. Curricular and scheduling changes need to be implemented. Other structural aspects of the school, such as the science fair, need to be brought in line with the inquiry approach. While this approach may be politically intimidating given the course of science reform and how it is affecting state assessments, teachers just need to try it out to see what advantages inquiry teaching holds for them and their students.

Several of the codes used to generate the accounts above came from the themes shared between the concerns (Fig. 2), but in the text of the teachers' letters one concern was often predominant. Several of the issues raised by the workshop evaluation are worth noting in these letters. The issue of time was hardly present in an overt sense, but it underlies much of what was said. Structure needs to be provided for meeting time and for discussion time. Classes need to be rescheduled in blocks. This change will take place over time, so meetings must occur regularly and future workshops need to be planned.

The issue of modeling also came out strongly in both concerns. Here it is seen in a wholly positive sense. The role of the teacher in the classroom is to mentor students in learning about science and investigating the world on their own. The role of the teacher as a colleague is for the entire faculty to aid one another—to be willing to open your door so that you can be the mentor or invite a mentor in for you.

These letters express goals and hopes, and so there is little antagonism or conflict present. Still, it is important to note how the practice concerns place demands on the profession, particularly through demands on time and changes in structures. Furthermore, many of these codes (2 for practice, 10 for profession) did not fit readily into the issues raised by the workshop evaluation. These codes represent issues such as attitude towards science, self-reflection, and structural change and expand the range of each concern, particularly the profession concern, in important directions.

Context Two: A Teacher's Journal

We examined one project lead teacher's reflective journal for the first month in which he was implementing what he had learned in the summer institute. The narrative below is written in the first person to draw attention to the personal nature of these observations. It also draws upon the journal author's own wording, from 36 coded statements, to remain true to his text. While it certainly is reasonable to expect some discussion of profession concerns and interaction with his colleagues in this journal, the complete lack of such reflection is notable. His writing focuses entirely on practice concerns. At the same time, as above, implications for profession concerns need to be considered as they arise.

- *Practice:* I believe that structure is an important aspect of the classroom. I admit it will be hard for me to give over some control to my students this year, but I will try my best. I feel this change is important enough to share with my students, and we talk on the first day of class about how science is going to be different this year. Although I am willing to give them more freedom to determine the course of their learning, discipline must still be maintained. This is as much an issue of respect for others as anything else, so we have spent some time our first few days learning how to work in groups. I gave my students several different exercises, in several different-sized groups, simply to learn how to communicate and work cooperatively. Even in this work, I am finding that my students surprise me, raising issues and answers that are quite unexpected. Unfortunately, by the time discussion is finished the class is over, and I must remind myself to revisit these issues so that

I can understand better how my students arrived at them.

Although my students have shown progress already, I continue with these cooperative exercises, giving them extended practice. More surprises await me: my students have begun to find parallels between the cooperative problem solving they do during science time with the problem solving they have done in math (I have them for both classes). They are beginning to see how the process influences the content of these problems, and I find myself learning with my students. These cooperative exercises have created much excitement, and now I can build on that by introducing our first science activities. I am finding that, as with the cooperative group exercises, I can adapt relevant curriculum materials to the science I wish to teach. I am also finding that my students, through their explorations, bring up the specific topics I wish to teach them before I get the chance! I can then use their experiences to springboard into teaching them the science that goes with the phenomena.

This turns out to be a useful pattern—I let my students explore, then I can introduce ideas in a more meaningful way. I do this at first to introduce science vocabulary terms. Next, I move on to critical aspects of the "scientific method," of doing inquiry. We first look at experimental design. We brainstorm investigable questions. We design research protocols. We constantly revisit terms and ideas, and we intersperse this all with activities structured to focus on one particular aspect of the whole at a time. Not only can I now respond to my students needs, but my students are helping one another more. It seems quite natural to them now ... maybe I should do more inquiry! We move on to a focus on the need for precision and accuracy, and we revisit ideas covered in the last week. We follow up, we cover another part of the inquiry process, and we revisit. I am pleasantly surprised at how it is paying off—the skills development of my students is very noticeable ... some of my girls have been practicing on their own! Some have even gone to the library to get out books for their own study. For me, this is a personal triumph.

I find now that I give my students many loosely structured opportunities to learn. I give them the materials and I direct their investigations by asking them for procedures, for observations, and for analyses. We spend a lot of time exploring, but I always bring them back to the structures of doing scientific inquiry which we worked so hard on from the start. They have gotten so good at figuring out how to solve problems, today I even let some groups settle some personal disputes on their own.

As is clear from this account, this teacher's primary concern is with structure and order. In other documents and accounts, he has related how this was his primary reason for getting involved with SP³ARK—learning how to ease up and let the students take some control. There is a clear progression in his journal from a high desire for structure and control to surrendering this control to the students. It is also clear, though, that this comes about because he has taught them how to control themselves and how to structure their own learning experiences. While he focuses overtly on this with respect to discipline early on, the same method is used to teach his students the process and ethic of inquiry. By the end of his first month of trying to change his practice, how far both he and his students have come is quite evident. Not only has he turned over responsibility to his students, both for their conduct and their learning, but also the students have earned this responsibility and respond in ways that constantly surprise and delight the teacher.

Structure arose in a different sense for the teacher letters above. It involved the structure of an organization and a culture, the school and teaching. What is relevant here is that the teacher *structured* (ordered, constrained) his lessons in ways that reflected the *structure* of the relevant culture (science, a respectful learning environment). Structure is both process and product as the process gets ingrained, subsumed into the natural behavior of the students. What issues does this process raise for the profession concern? What works successfully between teacher and student may lead to a source of antagonism between colleagues. This issue is considered in greater detail below.

profession codes do not correspond with the evaluation themes above, again describing a greater range for this concern, primarily in terms of structure, support, and for what concerns models of practice are needed.

Their comments on practice concerns are also full of challenge. They pay heed to the demands and the difficulties of teaching inquiry, but they also indicate again a more advanced level of concern. The comment about students conducting related investigations instead of the exact same experiment is particularly telling—instead of focusing on how excited the students are or how engaging hands-on learning can be, these teachers are seeing how their students, in arriving at the same place by different means, create a much richer context for learning for each other; they also see the teacher's role in helping students synthesize the information their classmates share in a way that leads towards discovering the principles and concepts of science.

The Intersection of Practice and Profession

We admit that, at face value, these two concerns may be seen as self-evident given the context of the study. The problem with self-evident statements is that they go unchallenged and unexamined far too long, and deserve careful re-examination in times of change and reform. Furthermore, we feel that the interaction of these two concerns has not been examined in great enough detail, nor has a model been put forth to conceptualize this interaction.

In trying to summarize our interpretations of these data, we do suggest a model that can aid in constructing understanding of how these concerns interact. The dialectic between teaching as practice and as a profession can be usefully seen as an instance of Vygotsky's Zone of Proximal Development (ZPD). Here, we do not mean the most popular conceptualization of the ZPD—that of the distance between a learner's actual and potential level of development. Vygotsky had a number of metaphors for describing the ZPD, and another important way of viewing it is as the interaction between scientific, academic, or disciplined knowledge and the spontaneous knowledge of everyday experience (Vygotsky, 1986). In this metaphor for development, Vygotsky acknowledges the importance of both types of knowledge. Disciplined knowledge is structured and logical and, therefore, it develops in advance of everyday knowledge. On the other hand, everyday knowledge is characterized by its vivaciousness. What it lacks in structure, it makes up for in its connection to real activity. Thus, each type of knowledge develops towards the other and, when they intertwine constructively, they create a rich base of knowledge that is both structured and grounded.

Utilizing this model, we would place practice in the role of the everyday and profession in the role of disciplined knowledge. These pairings seem natural, but they may also raise some objections. For instance, placing practice with the everyday may seem to dismiss the disciplined knowledge that teachers do have about classroom teaching. Our answer is to again point out Vygotsky's assertion that the "*development of scientific concepts runs ahead of the development of spontaneous concepts*" (1986, p. 147, italics in original). In other words, teachers would not be able to be teachers, to be the senior members of the classroom culture, if their own conceptualization of classroom practice was not fairly advanced. This means the interaction of the disciplined with the everyday already exists in practitioners, and that each day leads to further progress in the developing sense of pedagogical constructs as opposed to their theoretical meanings.

A similar question can be raised for the issue of pairing the education profession with disciplined knowledge. The lack of consensus among educators in how to best teach our children may be criticized as being the furthest thing from disciplined. Yet if such knowledge of teaching and learning does not exist here, then where? Even if such knowledge can be located elsewhere (such as in our universities and schools of education), we believe it *needs* to exist here. The classroom teacher is where these two strands interact, and so disciplined understanding of teaching and learning must remain close to that focal point for the interaction to be sustained.

Take as a case in point the illustrations above regarding issues of structure. As we mention above, structure is both an activity and a cultural artifact—a process and a product. Teachers structure lessons by constraining, directing, and molding. They know how and when to place these constraints based upon existing structures in a culture, whether a code of conduct to which students need to adhere or rules of evidence students must follow do demonstrate the veracity of their conclusions. In the journal examined above, the author successfully makes use of both structure-as-process and structure-as-product. In fact, he is able to convey a variety of structure-products by adapting one particular structure-process. With respect to inquiry learning, these structures of science are essential in developing a full understanding of science (NRC, 1996; AAAS, 1993).

What, then, do we find when we turn examine this view of structure through the concerns of the profession? Structure-products are, quite often, either absent or in anarchy. Multiple theories of best practice exist, even for fairly specific contexts such as eighth-grade earth science instruction. So, when teachers have developed their practice as best they can and need further structure, further disciplined understanding of how to teach even better, they cannot find the support or the products that they need, as is the case with the teachers we interviewed. This antagonism can exist in the opposite direction as well, particularly when considering structure-as-process. When the school culture requires individual teachers to adjust their practice to meet state tests, superintendent mandates, or national standards movements (whether these constraints are based on sound research or not), such efforts are often met with resistance from the field. What becomes clear, in this examination, is that the model for the dialectic interaction between practice and profession does exist; yet it has broken down.

Discussions From and With the Field

So, how do we prompt teachers to engage in a process of reconstructing themselves and their practices? There has been a cry against top-down reforms that leave teachers out of the decision-making process for a considerable period of time. Such "implementation-of-innovation" approaches are often supported for reasons that have little to do with actual classroom practice and are based on untenable, at worst, or unexamined assumptions (Heckman & Peterman, 1996). More recent studies of successful reform efforts examine notions of empowerment and local control and responsibility for reform. Haney, Czerniak, and Lumpe's (1996) investigation of science reform efforts in Ohio illustrates how success is related to teachers' attitudes towards reform behavior, their perception of social support for engaging in change, and the provision of necessary resources. This work is further supported by Reitzug's (1994) study of how principals can empower teachers to engage in reform efforts. Critical principal behaviors identified were creating a supportive environment for change, facilitating and stimulating change efforts, and making real change possible by leading efforts to secure the necessary resources. Such studies have shown the efficacy of reforms that place much of the power in the hands of teachers and principals.

Other areas of the literature base provide no clear course for change. What is the best means for getting teachers to engage in reform? Cornett (1995) argues forcefully that incentive programs such as merit pay are needed to drive successful reform. Firestone and Pennell (1993), in an earlier review, argue against differential incentive programs in favor of improving teacher commitment through increased participation, collaboration, and feedback. Peterson, McCarthy, and Elmore (1996) provide a convincing argument for placing the success of reform efforts in teacher learning, not in school structure (which can only play a supporting role). A number of researchers present equally compelling cases against this view. Louis, Marks, and Kruse (1996) present both large scale and case study evidence supporting the presence of a professional

community among teachers to be essential to reform. Louis and her colleagues (Louis, Kruse, & Raywid, 1996) describe the characteristics of these communities as: (1) having shared norms and values, (2) supporting and engaging in reflective dialog, (3) the de-privatization of practice and sharing between teachers, (4) a collective focus on student learning, and (5) a high level of collaboration. All of these features address the shortcomings of another common approach centered on teachers, that of teacher efficacy. As Ross (1995) illustrates, teachers can have high levels of personal efficacy and belief in their ability, yet institutional constraints can completely undermine these beliefs. Thus, in a climate that does not support teacher-based reform, individual teacher efforts are bound to run up against obstacles that can reverse any gains made.

So, much of the research on teacher change is inconclusive or downright contradictory. These contradictions may arise from seeing the dialectic between practice and profession as an either/or proposition. On the other hand, Louis' characteristics of a professional community do fit well with our use of the ZPD as a model for the interaction between these two concerns. Reform is not situated with teachers nor in school culture, but in the cooperative interaction of these elements. Further support can be found for the interaction between practice and profession in such communities. The problem of structure we discussed above is again a clear instance of this. Lawrenz's (1990) study of the extent to which science teacher behaviors correspond to their beliefs shows that while teachers value higher-order thinking skills above all other educational issues, neither their classroom behavior nor their assessment practices consistently engage students in practices known to help develop these skills. This inconsistency is often defended as a teacher's style, something all teachers have a right to. Ball points out just how great an impediment to reform this attitude is:

> "The common view that 'each teacher has to find his or her own style' is a direct result of working within a discourse of practice that maintains the individualism and isolation of teaching. This individualism not only makes it difficult to develop any sense of common standards but also makes it difficult to disagree. Masking disagreements hides individual struggles to practice wisely and so removes a good opportunity for learning. Politely refraining from critique and challenge, teachers have no forum for debating and improving their understandings. To the extent that teaching remains a smorgasbord of alternatives with no real sense of community, there is no basis for comparing or choosing alternative practices, no basis for real and helpful debate. This lack impedes the capacity to grow." (1996, p, 504)

It also runs counter to the ethic of inquiry. Again, if we can teach our students to engage in authentic inquiry, why will we not ask the same of ourselves?

We began this work with certain expectations and premises, and found ourselves arriving somewhere unexpected. Our investigation into teacher change did not get as far as we had believed it should, still by listening to our project teachers we have found our way to perhaps a more important and interesting place from which to view their work. The model we have developed in this paper gives us some insight into the various influences that empower or frustrate our teachers as they try to develop into inquiry science instructors. While this model certainly needs more work, and our project has areas to which it still needs to be applied, we believe it is a valuable means of avoiding the either/or duality of some past research approaches to reform that have contributed to a lack of consensus or clarity in how to engage in effective science reform efforts.

BEST COPY AVAILABLE

[1] This work was conducted with the support of NSF Grant 9630117. However, any opinions, findings, conclusions, and/or recommendations herein are those of the authors and do not necessarily reflect views of NSF. Correspondence regarding this work should be directed to: Robert Boyle, New York Academy of Sciences, 2 East 63rd Street, New York, NY, 10021. Phone: 212.838.0230x420. E-mail: rboyle@nyas.org.
[2] We would like to acknowledge the contribution of Dr. Rebecca Dyasi of the City College of New York, Dr. Mark Miksic of Queens College, and the Workshop Center at CCNY for hosting and leading this workshop. Their contribution to SP²ARK has been invaluable and an essential part of the project's success.
[3] This report can be obtained from the first author (note 1).

BEST COPY AVAILABLE

References

Abell, Sandra K., & Flick, Lawrence B. (1997). Who do we think we are anyway? *Journal of Research in Science Teaching, 34*, 425-427.

Addison, Richard B. (1989). Grounded interpretive research: An investigation of physician socialization. In Martin J. Packer & Richard B. Addison (Eds.), *Entering the Circle: Hermeneutic Investigation in Psychology*. Albany, NY: SUNY Press.

American Association for the Advancement of Science (1993). *Benchmarks for Science Literacy*. New York: Oxford University Press.

Ball, Deborah Loewenberg (1996). Teacher learning and the mathematics reforms: What we think we know and what we need to learn. *Phi Delta Kappan, 77*, 500-508.

Cornett, Lynn M. (1995). Lessons from 10 years of teacher improvement reforms. *Educational Leadership, 52*, 26-30.

Firestone, William A., & Pennell, James R. (1993). Teacher commitment, working conditions, and differential incentive policies. *Review of Educational Research, 63*, 489-525.

Gilligan, Carol (1982). *In a Different Voice: Psychological Theory and Women's Development*. Cambridge, MA: Harvard University Press.

Glaser, Barney G., & Strauss, Anselm L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Aldine de Gruyter.

Haney, Jodi J., Czerniak, Charlene M., & Lumpe, Andrew T. (1996). Teacher beliefs and intentions regarding the implementation of science education reform strands. *Journal for Research in Science Teaching, 33*, 971-993.

Heckman, Paul E., & Peterman, Francine (1996). Indigenous invention: New promise for school reform. *Teachers College Record, 98*, 307-327.

Louis, Karen Seashore, Kruse, Sharon, & Raywid, Mary Anne (1996). Putting teachers at the center of reform: Learning from schools and professional communities. NASSP Bulletin (National Association of Secondary School Principals), 80, 9-.

Louis, Karen Seashore, Marks, Helen M., & Kruse, Sharon (1996). Teacher's professional community in restructuring schools. *American Educational Research Journal, 33*, 757-798.

National Research Council (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

New York Academy of Sciences (1998). *Teacher Evaluations of an Inquiry Workshop: Reflections of the Workshop and Teachers' Attitudes towards Inquiry Science* (SP^{3}ARK Workshop Evaluation Report). New York: Author.

Peterson, Penelope L., McCarthy, Sarah J., and Elmore, Richard F. (1996). Learning from school restructuring. *American Educational Research Journal, 33*, 119-153.

Reitzug, Ulrich C. (1994). A case study of empowering principal behavior. *American Educational Research Journal, 31*, 283-307.

Strauss, Anselm, & Corbin, Juliet (1990). *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Newbury Park, CA: Sage.

Vygotsky, Lev (1986). *Thought and Language* (Alex Kozulin, Ed.). Cambridge, MA; The MIT Press.

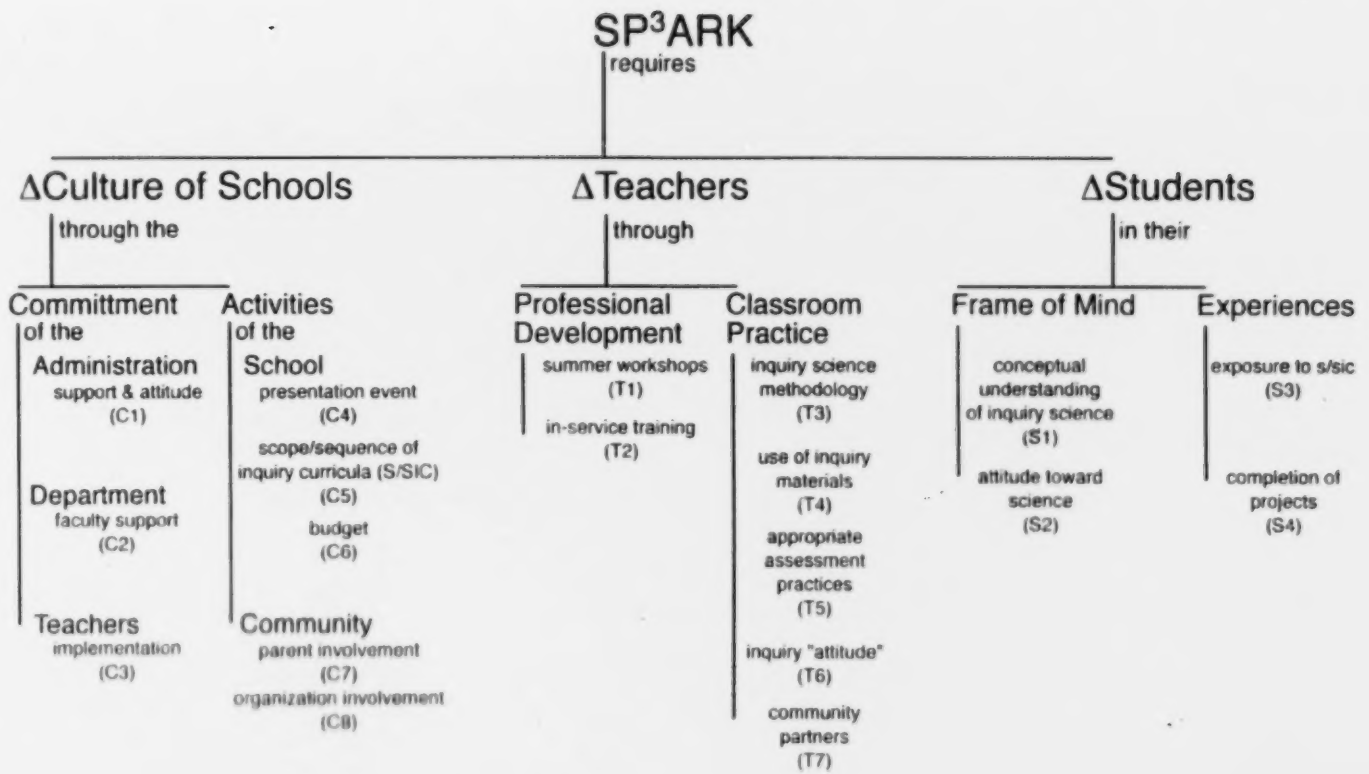

Figure 1: SP'ARK Conceptual Model

BEST COPY AVAILABLE

Number of Comments
(N=21 people)

#	+	-
3	20	3
2	1	3
1	-	8
0	-	7
M	2.95	1.10
(*SD*)	(0.22)	(1.04)

Table 1: Comments per Person

Value of Ratings
(N=63 possible)

Ivaluel	+	-
4	28	-
3	25	6
2	3	9
1	2	2
?	4	6
none	1	40
M	3.36	2.24
(*SD*)	(0.74)	(0.67)
N	58	17

Table 2: Rating Values

Positive Theme	N	Rating		Ranking	
		M	(*SD*)	*M*	(*SD*)
Social:	25	3.33	(0.82)	1.80	(0.71)
peer interaction	8	3.38	(1.06)	1.38	(0.52)
groupwork	10	3.10	(0.74)	1.80	(0.63)
discussion	7	3.67	(0.52)	2.29	(0.76)
Method:	21	3.53	(0.70)	1.86	(0.79)
time	3	3.00	(1.41)	1.33	(0.58)
hands on	3	3.33	(0.58)	1.67	(1.15)
freedom	8	3.43	(0.79)	1.88	(0.83)
review	1	4	-	2	-
inquiry	6	3.83	(0.41)	2.17	(0.75)
Materials	11	3.00	(0.87)	1.91	(0.94)
Curriculum	2	3.00	(0.00)	2.00	(1.41)
Models	6	3.33	(0.52)	2.67	(0.52)
Miscellaneous	1	4	-	3	-

Table 3a: Positive Comment Themes

Negative Theme	N	Rating		Ranking	
		M	(*SD*)	*M*	(*SD*)
Time: too much	7	2.17	(0.75)	1.00	(0.00)
Time: too little	4	2.33	(0.58)	1.00	(0.00)
Structure	6	2.00	(1.00)	1.83	(0.75)
Content	3	1*	-	2.00	(1.00)
Modeling	3	2.33	(0.58)	2.33	(0.58)
Miscellaneous	1	3	-	3	-

* two comments were unrated, leaving just one rated comment

Table 3b: Negative Comment Themes

Figure 2: Teacher Concerns

Appendix
Evaluation Instrument

On the cover sheet of the evaluation instrument were the following instructions:

> On page 2, would you please identify up to three aspects of the workshop that you found **most effective** in helping you gain an understanding about inquiry science teaching and learning. Write short (1-5 words) description, then circle the choice provided that best indicates how much of a contribution you felt this made. Finally, please describe in a short paragraph why you think this was effective.
>
> On page 3, please identify up to three aspects of the workshop that you found **least effective** in helping you gain an understanding about inquiry science. As above, write a short description of the item, circle the choice that indicates how much of a problem this was for you, then give a description of why you think this is so.
>
> On page 4, please give an **overall rating** for the workshop and feel free to add any additional comments you have in the space provided on this page.

Prompts from page two (the positive comments) began with:

1) State up to three aspects of the **CCNY Inquiry Workshop** that you think contributed the most to your professional development. Rate each on the scale provided as to their importance by circling the appropriate choice. Provide a short description as to why you think each was beneficial to you.

1.i What did you find *most* effective? _____

1	2	3	4
This was useful	This was important	This was very important	This was essential

Why do you think this?

Each prompt was followed by sufficient space to write a one-paragraph explanation of what they had identified as an issue. Directions were similar for the negative comments:

2) State up to three aspects of the **CCNY Inquiry Workshop** that you think detracted from the effectiveness of the experience. Rate each on the scale provided as to their importance by circling the appropriate choice. Provide a short description as to why you think each was detrimental to the workshop.

2.i What did you find *least* effective? _____

-1	-2	-3	-4
This was a slight problem	This needs minor changes	This needs major changes	This should be eliminated

Why do you think this?

The final page proved a space for filling in an overall rating (scale of 1-10) and prompted respondents to make general comments, as described above in the cover page instructions.

BEST COPY AVAILABLE